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(54) **Titre : PALIER DE PALE D'HELICE**
(54) **Title: PROPELLER BLADE MOUNTING SYSTEM**

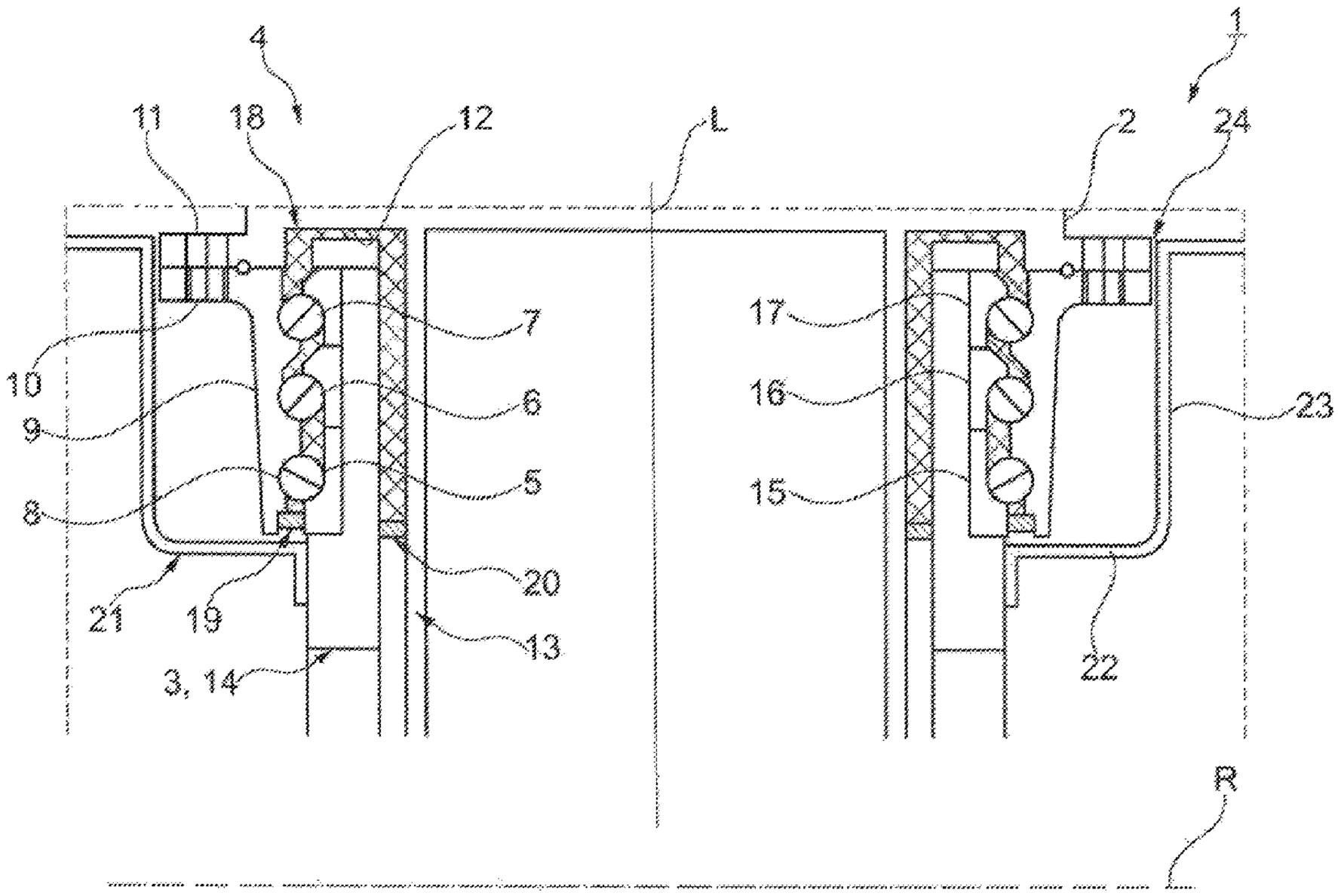

Fig. 1

(57) **Abrégé/Abstract:**
The invention concerns a propeller blade mounting system comprising a mounting system (4) on rolling bearings between a propeller hub (3) and a propeller blade (2), wherein: at least one bearing outer ring (9) is connected in rotationally fixed manner to

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(57) **Abrégé(suite)/Abstract(continued):**
the propeller blade (2); at least one bearing inner ring (15, 16, 17) is mounted on the propeller hub (3); a sleeve-shaped central portion (13) connected to the propeller blade (2) is disposed radially inside the bearing inner ring (15, 16, 17); and a lubricant chamber (18) is formed between the bearing outer ring (9) and the central section (13) in the radial direction, relative to the rotational axis (R) of the propeller hub (3), and is closed towards the exterior.

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(54) Bezeichnung : PROPELLERBLATTLAGERUNG

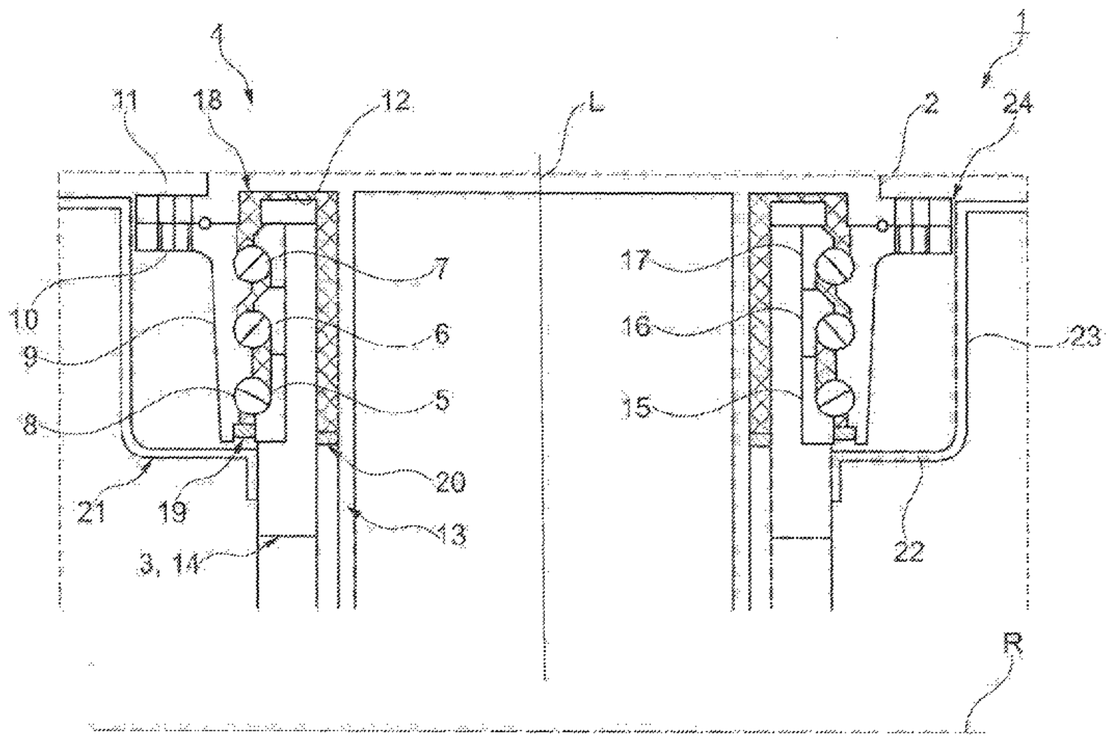

Fig. 1

(57) Abstract: The invention concerns a propeller blade mounting system comprising a mounting system (4) on rolling bearings between a propeller hub (3) and a propeller blade (2), wherein: at least one bearing outer ring (9) is connected in rotationally fixed manner to the propeller blade (2); at least one bearing inner ring (15, 16, 17) is mounted on the propeller hub (3); a sleeve-shaped central portion (13) connected to the propeller blade (2) is disposed radially inside the bearing inner ring (15, 16, 17); and a lubricant chamber (18) is formed between the bearing outer ring (9) and the central section (13) in the radial direction, relative to the rotational axis (R) of the propeller hub (3), and is closed towards the exterior.

(57) Zusammenfassung:

[Fortsetzung auf der nächsten Seite]

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Eine Propellerblattlagerung weist eine Wälzlagerung (4) zwischen einer Propellernabe (3) und einem Propellerblatt (2) auf, wobei - mindestens ein Lageraußenring (9) drehfest mit dem Propellerblatt (2) verbunden ist, - mindestens ein Lagerinnenring (15, 16, 17) an der Propellernabe (3) gehalten ist, - ein mit dem Propellerblatt (2) verbundener hülsenförmiger Zentralabschnitt(13) radial innerhalb des Lagerinnenrings (15, 16, 17) angeordnet ist, - zwischen dem Lageraußenring (9) und dem Zentralabschnitt (13) eine in Radialrichtung, bezogen auf die Rotationsachse (R) der Propellernabe (3), nach außen hin geschlossene Schmierstoffkammer (18) gebildet ist.

PROPELLER BLADE MOUNTING SYSTEM

Field of the Invention

The invention concerns a propeller blade bearing for adjustable propeller blades of aircraft, whereby the propeller blades are pivotable about their respective longitudinal axis by means of rolling bearings.

Background of the Invention

A bearing assembly with which propeller blades of an aircraft are adjustably mounted to a hub is known, for example, from DE 10 2004 060 022 A1. The bearing assembly is comprised of a primary and a secondary adjustment bearing that are each configured as a ball bearing and are components of a pre-assembled structural unit. A lubricant is mainly stored in the bearing assembly and is held within a certain volume by, among other things, lubricating oil surge rings that enclose bearing rings.

An apparatus for propeller pitch control, which comprises a rolling bearing assembly with balls and rollers as rolling elements, is known, for example, from GB 2 244 525 A. A preload force is hereby applied between a first rolling element row formed from balls and a second rolling element row formed from balls. As with the bearing assembly known from DE 10 2004 060 022 A1, here too an adjustable propeller blade is connected to inner rings of the bearing, while the associated outer rings are on the hub.

The adjustability of propeller blades is required in particular for propfan engines. An example of a shrouded propfan engine with adjustable blades is disclosed in DE 38 18 466 Cl. In contrast US 2012/0134822 A1 describes an unshrouded propfan engine.

Propfan engines are aircraft engines that have a particularly high by-pass ratio to increase efficiency over older types of engines. A high air flow rate is generated by propeller blades, which, as is known from the cited state of the art, can be located either within a shroud or

outside of any housing. To adapt the drive power to the current flight situation while keeping the rotational speed of the drive motor as constant as possible, the angle of attack of the propeller blades is adjusted by rotating the propeller blades about their axes. For this purpose, each propeller blade is rotatably connected to the hub of the propeller by means of a rolling bearing.

To prevent wear in the contact points of the rolling elements, the rolling bearing is typically situated in a space that is completely filled with oil. Due to the rotational movement of the rotor, the system experiences centrifugal acceleration that can correspond to approximately 500 times normal gravitational acceleration or more. A secure seal of the oil chamber under the resulting hydraulic pressure is crucial for the reliability and durability of the rolling bearing, and to prevent outwardly visible leaks.

Task of the Invention

The underlying task of the invention is to specify a propeller blade bearing assembly that is further developed compared to the state of the art, is in particular suitable for the high-speed rotating drives of aircraft, and which exhibits a rolling bearing that is particularly easy to lubricate, assemble and service.

Description of the Invention

This task is inventively solved by a propeller blade bearing with the features of Claim 1.

The propeller blade bearing exhibits a rolling bearing between a propeller hub and a propeller blade, whereby

- at least one bearing outer ring is disposed on the propeller blade, i.e. it is either a component of the propeller blade or is rigidly connected to it,
- at least one bearing inner ring is disposed on the propeller hub, i.e. it is either a component of the propeller hub or is mounted to it,

- a sleeve-shaped central section, that is rigidly connected to the propeller blade, is disposed radially inward of the bearing inner ring of the rolling bearing,
- a lubricant chamber, closed to the outside in radial direction relative to the axis of rotation of the propeller hub, is formed between the bearing outer ring and the central section.

In the present case the term "propeller blade in the broader sense" means the entire rotor blade that is adjustably mounted on the hub, even if it is composed of several individual parts, for example a blade root and an attached blade, i.e. a propeller blade in the narrow sense. The propeller blade bearing is the mounting of the propeller blade in the broader sense on the propeller hub.

The rolling bearing of the propeller blade bearing assembly is preferably configured as a multi-row, in particular two or three-row, bearing. The rolling bearing can, however, also exhibit four, five, or six rows of rolling elements, for example. Balls as wells as needles, cylindrical rollers and tapered rollers can be used as rolling elements. A combination of different rolling element forms and sizes within the rolling bearing is possible as well. The rolling elements can be made of rolling bearing steel or a ceramic material, such as silicon nitride. Rolling elements can be separated from one another by a cage, by cage segments each holding a plurality of rolling elements or by spacer elements, in each case disposed between two rolling elements. Metals and plastics, in particular fiber-reinforced plastics, can be used as cage materials.

In one possible embodiment, the rolling bearing is configured as a three-row angular contact ball bearing, whereby the three rows of rolling elements are at different distances from the rotation axis of the propeller hub. With this configuration, the propeller blade bearing is primarily designed to absorb forces acting radially to the outside. Preloading between the rows of rolling elements ensures the absence of play in the propeller blade bearing assembly. At the same time, mechanical stresses are evenly distributed onto the individual rows of rolling elements and overall kept low.

In a particularly advantageous configuration, the row of rolling elements of the ball bearing with the smallest distance from the axis of rotation of the propeller hub forms an O arrangement in conjunction with the middle, second row of rolling elements and the associated bearing rings adjacent to them, while the outermost, i.e. third, row of rolling elements, furthest away from the propeller hub, is disposed between the bearing rings at a pressure angle, the orientation of which corresponds to the pressure angle of the middle row of rolling elements. In a particularly preferred configuration, the pressure angle of the middle row of rolling elements is equivalent to the pressure angle of the outermost row of rolling elements, or differs therefrom by not more than 10°, in particular by no more than 5°. The rolling bearing can, in a similar manner, also be constructed of four or more rows, whereby the pressure angle of the fourth and, as the case may be, at least one other row of rolling elements is preferably equivalent to the pressure angle of the third row of rolling elements.

The two, three or multi-row rolling bearing can exhibit one single outer ring and multiple inner rings. To do so, the one-piece outer ring can be connected to the propeller blade or a carrier holding the propeller blade by means of a mounting flange formed to fit onto the one-piece outer ring. The bearing outer ring is preferably made of steel and exhibits a hardness of 300 to 500 HV1 and edge layer hardened rolling contact surfaces with a hardness of more than 700 HV1. The surfaces of the outer ring that are exposed to the environment can exhibit a coating to protect against corrosion. The inner rings can be positioned on a bearing pin, which is a component of the hub, and clamped together. The rolling contact surfaces of all the bearing rings can exhibit a wear-resistant coating or a surface treatment, in particular carbonitriding.

One particular advantage of the radially outward closed lubricant chamber lies in the fact that, to prevent an outflow of the lubricant in radial direction relative to the axis of rotation of the propeller, there is no need for a seal between parts that can move with respect to one another. Seals between mutually movable, in particular pivotable, parts on the other hand, can be disposed on the, with respect to the axis of rotation of the propeller, radially inward side of the lubricant chamber. Here a first seal acts between the outer ring and the propeller hub, whereby

this first outer seal, on its inner side with respect to the longitudinal axis of the propeller blade, is in direct contact with a bearing inner ring or another part that is fixed to the rotor hub. A second inner seal forming a seal between the propeller hub and the central section of the propeller blade is, on its outer side with respect to the longitudinal axis of the propeller blade, likewise in contact with a component of the hub, in particular a sleeve-shaped rotor blade carrier holding the inner rings. A preferred configuration makes reliable tightness of the lubricant chamber at hydraulic pressure greater than 10 bar possible. This hydraulic pressure is generated by centrifugal acceleration and applied, with respect to the axis of rotation of the propeller hub in outward direction, by the lubricant.

According to a preferred further development, the outer ring is surrounded by a guard ring, arranged concentrically to the bearing rings and connected to the hub, for example directly fixed to the hub, that can be made, for example of sheet steel or a composite material. In a section of adjustable components of the propeller blade bearing concentrically surrounding the longitudinal axis of the propeller blade, in particular a flange of the outer ring or the propeller blade, this guard ring can be at such a small distance that an additional, non-contacting seal is provided.

The sleeve-shaped central section of the propeller blade, which occupies a space within the bearing inner rings and forms an inner wall of the lubricant chamber, is preferably a component of an adjustment device for adjusting the angle of attack of the propeller blade. The transmission of a torque, that pivots the propeller blade about its longitudinal axis in terms of a pitch adjustment, can be accomplished by means of electrical and/or hydraulic adjusting mechanisms.

The advantage of the invention is, in particular, that the propeller blade bearing is designed as a pre-assembled unit that can, to a large extent, be connected to the rotor hub and the propeller blade without additional adjustment activity. Due to the fact that the sealing of the oil chamber, i.e. the lubricant chamber, between mutually movable parts occurs close to the axis of rotation of the rotor hub, with respect to the rotor axis radially inward of the rolling

bearing, the hydraulic pressure of the oil during rotation does not act on dynamic seals. In a space above the rolling bearing that is subjected to hydraulic pressure, however, there are at most static seals.

Brief Description of the Drawing

A design example of the invention will be explained in more detail in the following with the aid of a drawing. In a simplified cross-sectional view:

Fig. 1 shows a propeller blade bearing of an aircraft.

Detailed Description of the Drawing

A propeller blade bearing, with regard to the principal function of which reference is made to the prior state of the art cited at the outset, of a not further depicted aircraft, and identified overall by the reference sign 1, is schematically shown in Figure 1.

The propeller blade bearing 1 serves to pivotably mount a propeller blade 2 to a propeller hub 3. The axis of rotation of the propeller hub 3 is labelled with R; the longitudinal axis of the propeller blade 2 is labelled with L. A rolling bearing 4, designed as a three-row ball bearing, is provided to adjust the angle of attack of the propeller blade 2.

The three rows of rolling elements of the rolling bearing 4 are referred to as inner row 5, middle row 6 and outer row 7. The rolling elements, i.e. balls, are uniformly identified by the reference sign 8. The inner row 5 exhibits the smallest distance from the axis of rotation R of the propeller hub 3 and the outer row 7 exhibits the greatest. All three rows 5, 6, 7 of the rolling elements 8 are equidistant from the longitudinal axis L of the propeller blade 7, i.e. the pivoting axis of the rolling bearing 4 used for the pitch adjustment.

The rolling bearing 4 is configured as an angular contact ball bearing exhibiting a single outer ring 9. A flange 10 that is fixed to the propeller blade 2 is integrally formed on the outer ring

9. For this purpose, the propeller blade 2 likewise exhibits a mounting flange 11. Radially inward of the mounting flange 11, with respect to the longitudinal axis L, there is an annular end face 12 of the propeller blade 2. The end face 12 is limited radially inward, again with respect to the longitudinal axis L, by a sleeve-shaped central section 13, which is a component of the propeller blade 2. The central section 13, that is identical to the propeller blade 2, or is at least fixed to it, can be rotated by means of a not depicted mechanism for adjusting the angle of attack of the propeller blades 2, and therefore constitutes an adjustment ring of a not further depicted adjustment device.

An annular space, closed to the outside by the end face 12, and into which a sleeve-shaped rotor blade carrier 14 that is fixed to the propeller hub 3 protrudes, is formed between the outer ring 9 and the central section 13. Clamped onto the rotor blade carrier 14 are three inner rings 15, 16, 17, off which the rows of balls 5, 6, 7 roll. A contiguous lubricant chamber 18 is formed between the inner rings 15, 16, 17 and the outer ring 9, between the rotor blade carrier 14 holding the inner rings 15, 16, 17 and the end face 12 of the propeller blade 2, and between the rotor blade carrier 14 and the central section 13.

As the propeller hub 3 rotates, the lubricant in the lubricant chamber 18 is pushed radially outwardly and thus against the closed end face 12. To also prevent outflow of lubricant from the lubricant chamber 18 when the propeller hub 3 is idle, the lubricant chamber is closed with respect to the axis of rotation R radially to the inside by an external seal 19, which forms a seal between the outer ring 9 and the innermost inner ring 15, and by an inner seal 20, which forms a seal between the rotor blade carrier 14 and the central section 13. The entire rolling bearing 4 is covered by a guard ring 21 that is mounted on the rotor blade carrier 14. In the sectional view of Fig. 1, the guard ring 21 exhibits an angled shape with a flat disc section 22, lying in a plane normal to the longitudinal axis L, and an adjacent cylindrical wall section 23. The wall section 23 surrounds the flange 10 of the outer ring 9 and the mounting flange 11 to form an annular gap 24, which provides protection against the intrusion of foreign bodies into the propeller bearing 1.

The configuration of the bearing rings 9, 15, 16, 17 of the rolling bearing 4 is attuned to the aerodynamic forces and mass forces occurring during operation. The inner and middle rows of balls 5, 6 are designed as components of a two-rowed angular contact ball bearing in an O arrangement inside the rolling bearing 4. Thus the middle row of balls 6 supports the propeller blade 2 in radial direction to the outside with respect to the rotational axis R, while the inner row of balls 5 provides support to the inside. With regard to the alignment of the pressure lines passing through the rolling elements 8, the assembly situation of the outer row of balls 7 corresponds to that of the middle row of balls 6. Overall, the three-row rolling bearing 4 thus provides a twofold support of the propeller blade 2 to the outside and a single support to the inside.

During operation of the aircraft exhibiting the propeller blade 1, in particular an aircraft with a propfan drive, the rolling elements 8 and the rolling contact surfaces of the bearing rings 9, 15, 16, 17, on which the rolling elements 8 roll, are subjected to a variety of stresses, also as a result of vibrations. The rolling elements 8 designed in accordance with these stresses can be made from through-hardened rolling bearing steel or a high-performance ceramic. Through-hardened or edge layer hardened rolling bearing steel is suitable for the manufacturing of the bearing rings 9, 15, 16, and 17. The materials from which the outer ring 9 and the inner rings 15, 16, 17 are manufactured is not necessarily identical. The bearing rings 9, 15, 16, 17 can, at least partially, be provided with a wear-resistant coating in the rolling contact area.

The propeller blade bearing 1 is suitable not only for propfan engines, but also, for example, for turboprop engines of aircraft. In any case, one particular advantage of the propeller blade bearing 1 is the fact that it is very easily accessible for inspection and maintenance purposes.

List of Reference Numbers

1 Propeller blade bearing
2 Propeller blade
3 Propeller hub
4 Rolling bearing
5 Inner row of balls
6 Middle row of balls
7 Outer row of balls
8 Rolling elements
9 Outer ring
10 Flange
11 Mounting flange
12 Face
13 Central section
14 Rotor blade carrier
15 Inner ring
16 Inner ring
17 Inner ring
18 Lubricant chamber
19 Seal
20 Seal
21 Guard ring
22 Disc section
23 Wall section
24 Annular gap

L Longitudinal axis
R Axis of rotation

Claims

1. Propeller blade bearing, with a rolling bearing (4) between a propeller hub (3) and a propeller blade (2), whereby
   - at least one bearing outer ring (9) is connected to the propeller blade (2) in a torque-proof manner,
   - at least one bearing inner ring (15, 16, 17) is held on the propeller hub (3),
   - a sleeve-shaped central section (13), connected to the propeller blade (2), is disposed radially inward of the bearing inner ring (15, 16, 17),
   - a lubricant chamber (18), closed to the outside in radial direction relative to the axis of rotation (R) of the propeller hub (3), is formed between the bearing outer ring (9) and the central section (13).

2. Propeller blade bearing according to Claim 1, characterized in that the rolling bearing (4) is configured as at least a three-row bearing, in particular a ball bearing.

3. Propeller blade bearing according to Claim 2, characterized in that the row (5) of rolling elements (8) of the rolling bearing (4) with the smallest distance from the rotational axis (R) of the propeller hub (3) forms an O arrangement in conjunction with the second row (6) of rolling elements (8) and the associated bearing rings (15, 16) adjacent to them, while at least one other row (7) of rolling elements (8), further away from the propeller hub (3), is disposed between the bearing rings (9, 17) at a pressure angle, the orientation of which corresponds to the pressure angle of the second row (6) of rolling elements (8).

4. Propeller blade bearing according to one of Claims 1 to 3, characterized in that the rolling bearing exhibits a single outer ring (9) and a plurality of inner rings (15, 16, 17).

5. Propeller blade bearing according to one of Claims 1 to 4, characterized in that, on its radially inward side, the lubricant chamber (18) is sealed by a first seal (19), disposed between the outer ring (9) and the propeller hub (3), and by a second seal (20), disposed between the propeller hub (3) and the central section (13) of the propeller blade (2).

6. Propeller blade bearing according to Claim 5, characterized in that the lubricant chamber (18) is configured in such a way that its leak tightness is given at a hydraulic pressure of at least 10 bar generated by centrifugal acceleration and outwardly directed, relative to the axis of rotation (R) of the propeller hub (3).

7. Propeller blade bearing according to Claim 5 or 6, characterized in that the first seal (19) is in contact with an inner ring (15) of the rolling bearing (4).

8. Propeller blade bearing according to one of Claims 5 to 7, characterized in that contacted the second seal (20) is in contact with a sleeve-shaped rotor blade carrier (14) that holds the inner ring (15, 16, 17).

9. Propeller blade bearing according to one of Claims 1 to 8, characterized in that the outer ring (9) is surrounded by a guard ring (21) that is arranged concentrically to the bearing rings (9, 15, 16, 17) and is connected to the propeller hub (3).

10. Propeller blade bearing according to one of Claims 1 to 9, characterized in that the central section (13) of the propeller blade (2) is configured as part of an adjustment device to adjust the pitch angle of the propeller blade (2).

11. Propeller blade bearing according to one of Claims 1 to 10, characterized in that a flange (11), which can be connected to the propeller blade (2), is integrally formed on the bearing outer ring (9).

12. Propeller blade bearing according to one of Claims 1 to 11, characterized in that the bearing outer ring (9) is made of steel and exhibits a hardness of 300 to 500 HV1 and edge layer hardened rolling contact surfaces with a hardness of more than 700 HV1.

13. Propeller blade bearing according to one of Claims 1 to 12, characterized in that the bearing outer ring (9) exhibits a partial anti-corrosion coating.

14. Propeller blade bearing according to one of Claims 1 to 13, characterized in that rolling elements (8) arranged in a row (5, 6, 7) within the rolling bearing (4) are kept separated from each other by elements made of synthetic material.

15. Propeller blade bearing according to one of Claims 1 to 14, characterized in that at least one rolling contact surface of the bearing outer ring (9), the bearing inner rings (5, 6, 7) and the rolling elements (8) exhibits a wear-protection layer.

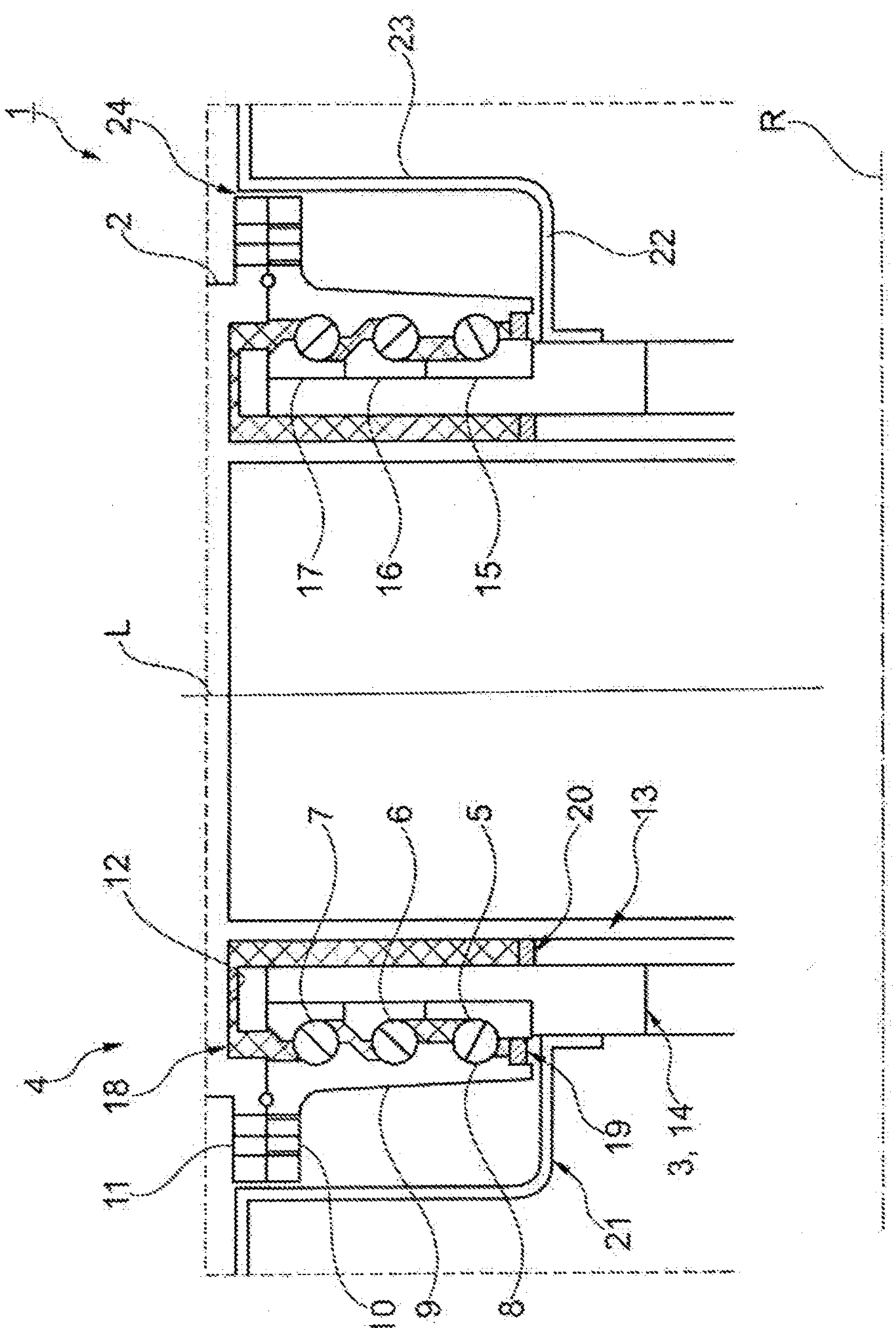

Fig. 1

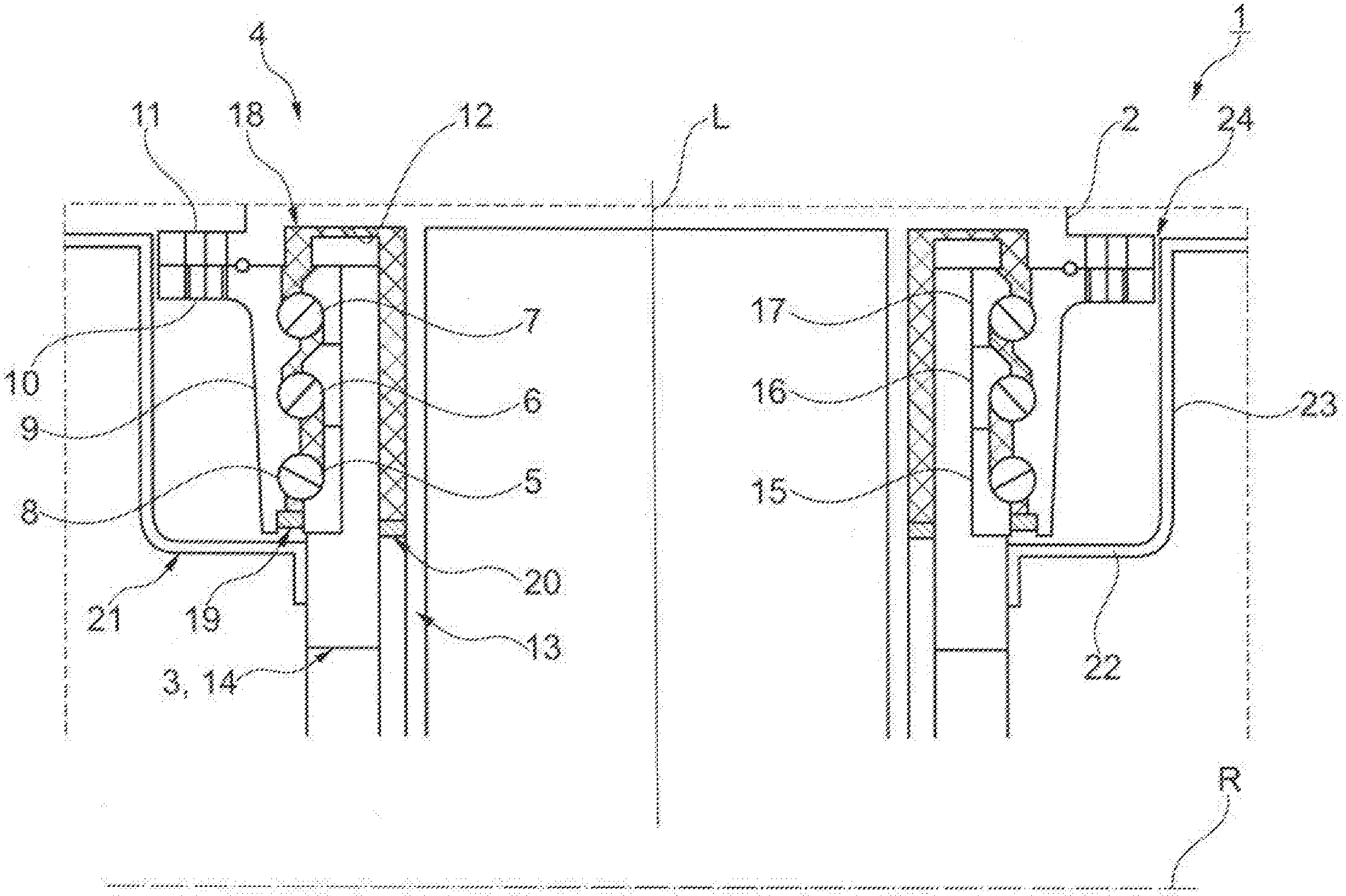

Fig. 1